

Document ID	Page	Kind	Code	Source
US 6461494 B1	41			USPAT
US 6309524 B1	45			USPAT
US 6080291 A	21			USPAT
US 5985126 A	60			USPAT
US 5980706 A	33			USPAT
US 0627401 A	3			USPAT

US-PAT-NO: 6461494

DOCUMENT-IDENTIFIER: US 6461494 B1

See image for Certificate of Correction**

TITLE: Methods for plating semiconductor workpieces using a workpiece-engaging electrode assembly with sealing boot

----- KWIC -----

US Patent No. - PN (1): 6461494

United States Patent

Batz, Jr. et al.

(10) Patent No.: US 6,461,494 B1
(45) Date of Patent: Oct. 8, 2002

(54) METHODS FOR PLATING SEMICONDUCTOR WORKPIECES USING A WORKPIECE-ENGAGING ELECTRODE ASSEMBLY WITH SEALING BOOT

Inventors: Robert W. Batz, Jr.; Kenneth C. Hangan; Harry J. Geyer; Robert W. Berner, all of Kalispell, MT (US)

(73) Assignee: Semiflool, Inc., Kalispell, MT (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 09/390,091

(22) Filed: Sep. 3, 1999

Related U.S. Application Data

(63) Continuation of application No. 08/940,685, filed on Sep. 30, 1997, now Pat. No. 6,001,234.

(51) Int. Cl. C25D 7/12; C25D 17/06

(52) U.S. Cl. 205/123; 204/297.08; 205/143; 205/157

(58) Field of Search 205/123, 143, 205/157, 291, 640, 668, 118; 204/224 R, 265, 287, 297.01, 297.06, 297.08

(56) References Cited

U.S. PATENT DOCUMENTS

4,192,729 A * 3/1980 Cancellari et al. 204/272

5,078,852 A * 1/1992 Yeo et al. 204/297.05

OTHER PUBLICATIONS

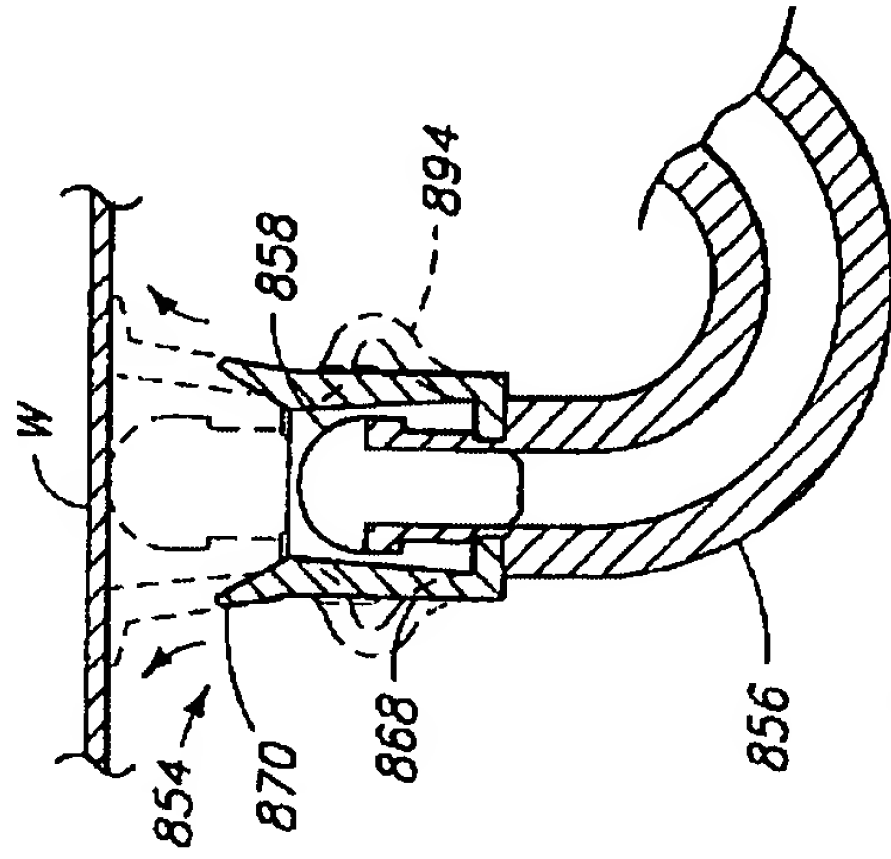
Merriam-Webster's Collegiate Dictionary, Tenth Edition, Merriam-Webster, Inc., Springfield, Massachusetts, p. 820, 1997 No Month Available.*

* cited by examiner

Primary Examiner—Kathryn Gorgos
Assistant Examiner—William T. Leader
(74) Attorney, Agent, or Firm—Poli & Associates, L.L.C.
(57) ABSTRACT

Methods used in semiconductor electroplating systems, such as for plating copper, onto a semiconductor wafer or other semiconductor workpiece. The methods apply to patterned metal layers plated onto seed layer which is partially protected by an overlying photoresist or other coating. The methods employ an electrode assembly which has a boot which seals about a contact face of the electrode. The sealing is performed by engaging the seal against photoresist to prevent corrosion of the seal layer. The area enclosed by the sealing includes a via which is surrounded by the seal. The electrode contact extends through the via to provide electrical contact with the metallic seed layer. Plating of copper or other metal proceeds at exposed seed layer areas.

5 Claims, 38 Drawing Sheets



	Document ID	Page	B	U	S	C	P	Kind Codes	Source
1	US 6461494 B1	61							USPAT
2	US 6309524 B1	45							USPAT
3	US 6080291 A	21							USPAT
4	US 5985126 A	60							USPAT
5	US 5980706 A	33							USPAT
6	US 0627401 A	3							USPAT

US-PAT-NO: 6461494

DOCUMENT-IDENTIFIER: US 6461494 B1

See image for Certificate of Correction**

TITLE: Methods for plating semiconductor workpieces using a workpiece-engaging electrode assembly with sealing boot

----- KWIC -----

US Patent No. - PN (1):
6461494

US 6,461,494 B1

35

electroplating to occur upon exposed seed layer areas of the processed surface. Such exposed seed layer areas may be trenches, vias or other features where the photoresist layer 564 is not present to cover the seed layer 562. The electrical current causes electroplating to occur on such exposed seed layer areas.

Still further, the methods preferably include excluding plating, or other processing liquid from the sealed space to substantially reduce or eliminate plating or other action in the area immediately adjacent to the contact with the electrode.

The methods described above are of particular relevance to plating copper onto semiconductor devices.

Plating Bowl Assembly

FIG. 42 shows an electroplating bowl assembly 303. The process bowl assembly consists of a process bowl or plating vessel 316 having an outer bowl side wall 617, bowl bottom 319, and bowl rim assembly 314. The process bowl is preferably circular in horizontal cross-section and generally cylindrical in shape although other shapes of process bowl may be possible.

The invention further advantageously includes a cup assembly 320 which is disposed within process bowl vessel 316. Cup assembly 320 includes a fluid cup portion 321 having a cup side 322 and a cup bottom 323. As with the outer process bowl, the fluid cup 321 is preferably circular in horizontal cross-section and cylindrical in shape. The cup assembly also has a depending skirt 371 which extends below the cup bottom 323 and has flutes 372 open there-through for fluid communication and release of any gas that might collect as the chamber below fills with liquid. The cup assembly can be made using upper and lower portions which couple together at a cup main joint 387. The cup is preferably made from polypropylene or other suitable material, which is advantageously dielectric.

The lower opening in the cup bottom wall is connected to a riser tube 361 which is adjustable in height relative thereto by a threaded connection. The riser tube seals between the bottom wall 319 of the process bowl and the cup bottom 323. The riser tube is preferably made from polypropylene or other suitable dielectric material. A fitting 362 connects the riser tube 361 and the fluid inlet line 325 to allow adjustment of the anode vertical position. The fitting 362 can accommodate height adjustment of both the riser tube and inlet line 325. The inlet line is made from a conductive material, such as titanium and is used to conduct electrical current to the anode 324, as well as supply fluid to the cup.

Process fluid is provided to the cup through fluid inlet line 325. The fluid inlet line rises through riser tube 361 and bowl bottom opening 327 and through cup fluid inlet openings 324. Plating fluid fills the cup portion 321 through opening 324 as supplied by a plating fluid pump (not shown) or other suitable supply which provides the fluid under at least some pressure for delivery.

The upper edge of the cup side wall 322 forms a weir which determines the level of plating liquid within the cup. Excess fluid pours over this top edge surface into the overflow chamber 345. The fluid held in the overflow chamber 345 is sensed by two level detectors 351 and 352. One level detector is used to sense a desired high level and the other is used to sense an overflow condition. The level of liquid is preferably maintained within a desired range for stability of operation. This can be done using several different outflow configurations. A preferred configuration is to sense the high level using detector 351 and then drain fluid through a drain line as controlled by a control valve. It is also possible to use a standpipe arrangement (not illustrate), and

36

such is used as a final overflow protection device in the preferred plating station 303. More complex level controls are also possible.

The outflow liquid from chamber 345 is preferably returned to a suitable reservoir. The liquid can then be treated with additional plating chemicals or other constituents of the plating or other process liquid and used again.

The plating bowl assembly 303 further includes an anode 334. In the preferred uses according to this invention, the anode is a consumable anode used in connection with the plating of copper or other metals onto semiconductor materials. The specific anode will vary depending upon the metal being plated and other specifics of the plating liquid being used. A number of different consumable anodes which are commercially available may be used as anode 334.

FIG. 42 also shows a diffusion plate 375 provide above the anode 334 for rendering the fluid plating bath above the diffusion plate with less turbulence. Fluid passages are provided over all or a portion of the diffusion plate to allow fluid communication there-through. The height of the diffusion plate is adjustable using three diffuser height adjustment mechanisms 386 and secured by three mounting fasteners 389.

Plating Anode Shield

The invention also includes an anode shield 393 which can be secured to the consumable anode 334 using anode shield fasteners 394. The anode shield and anode shield fasteners are preferably made from a dielectric material, such as polyvinylidene fluoride or polypropylene. The anode shield is advantageously about 2-5 millimeters thick, more preferably about 3 millimeters thick.

The anode shield serves to electrically isolate and physically protect the back side of the anode. It also reduces the consumption of organic plating liquid additives consumed. Although the exact mechanism may not be known at this time, the anode shield is believed to prevent disruption of certain materials which develop over time on the back side of the anode. If the anode is left unshielded the organic chemical plating additives are consumed at a significantly greater rate. With the shield in place these additives are consumed less. The shield is preferably positioned on the anode so as to shield it from direct impingement by the incoming plating liquid.

The invention thus also include methods for plating which include other method steps described herein combination with shielding a consumable anode from direct flow of plating liquids using a dielectric anode shield.

In compliance with the statute, the invention has been described in language more or less specific as to structural and methodological features. It is to be understood, however, that the invention is not limited to the specific features shown and described, since the means herein disclosed comprise preferred forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims appropriately interpreted in accordance with the doctrine of equivalents.

What is claimed is:

1. A method for electrochemically processing a wafer, comprising:
selecting a contact assembly having at least one electrical contact and a yieldable sealing member, said yieldable sealing member having a bellows wall structure;
engaging the surface of the wafer using the yieldable sealing member, said yieldable sealing member bearing against the surface of the wafer to form a barrier therewith that inhibits entry of processing fluid into a

	Document ID	Page	U	S	C	P	Kind Codes	Source
1	US 6461494 B1	61	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
2	US 6309524 B1	45	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
3	US 6080291 A	21	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
4	US 5985126 A	60	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
5	US 5980706 A	33	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
6	US 0627401 A	3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT

US-PAT-NO: 6461494
DOCUMENT-IDENTIFIER: US 6461494 B1
See image for Certificate of Correction

TITLE: Methods for plating semiconductor workpieces using a
workpiece-engaging electrode assembly with sealing boot

----- KWIC -----

US Patent No. - PN (1):
6461494

US 6,461,494 B1

37

sealed space forming a first region that includes the at least one electrical contact, the yieldable sealing member also defining a second region external to said yieldable sealing member;
contacting a contact point on the surface of the wafer with said electrical contact to form an electrically conductive connection between the contact assembly and said wafer, said contact point being disposed in the first region;
contacting the surface of the wafer corresponding to the second region with an electrolyte pursuant to electrochemical processing of the surface;
supplying electrical power through the electrical contact to the wafer to electrochemically process the portion of the wafer lying in the second region.

38

2. A method as claimed in claim 1 wherein said yieldable sealing member includes a rim portion for engaging the surface of the wafer and forming a barrier therebetween.
3. A method as claimed in claim 2 wherein when contacting said contact point the yieldable sealing member yieldably deforms for enabling the electrical contact to contact said contacting point.
4. A method as claimed in claim 3 wherein the rim portion of said yieldable sealing member splay outward when yieldably deforming.
5. A method as claimed in claim 1 wherein said electrochemical process includes an electroplating process.

• • • • •

Document ID	Pages	Y	S	V	S	C	P	Kind Codes	Source
US 6274013 B1	33								USPAT
US 6031234 A	59								USPAT

US-PAT-NO: 6274013
DOCUMENT-IDENTIFIER: US 6274013 B1
TITLE: Electrode semiconductor workpiece holder

----- KWIC -----

US Patent No. - PN (1):
6274013

(12) **United States Patent**
Bleck et al.

(10) Patent No.: **US 6,274,013 B1**
(45) Date of Patent: ***Aug. 14, 2001**

(54) **ELECTRODE SEMICONDUCTOR
WORKPIECE HOLDER**

(75) Inventors: **Martin Bleck; Kenneth C. Haugan;
Larry R. Radloff; Harry Geyer, all of
Kalispell, MT (US)**

(73) Assignee: **Semiltool, Inc., Kalispell, MT (US)**

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **09/300,610**

(22) Filed: **Apr. 27, 1999**

Related U.S. Application Data

(63) Continuation of application No. 08/680,057, filed on Jul. 15,
1996, now Pat. No. 5,980,706.

(51) Int. Cl. **C25D 17/06**

(52) U.S. Cl. **204/297.08; 118/729; 118/503;**
204/297.01; 204/297.09; 204/297.1; 204/297.14

(58) Field of Search **204/297 R, 297 W;**
204/280, 286, 224 R, 297.01, 297.08, 297.09,
297.1, 297.14; 205/123; 118/72 B, 729,
730, 500, 503; 156/345 WH; 269/24, 27

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,948,502 • 4/1976 Waller et al. 269/27

4,192,729 • 3/1980 Candelari 204/272
5,013,015 • 5/1991 Fatheree 269/24
5,078,852 • 1/1992 Yee et al. 204/297.03

OTHER PUBLICATIONS

The American Heritage Dictionary of the English Language,
William Morris, editor, Houghton Mifflin Co., Boston, pp
824, 1976 Month of publication not available.*

* cited by examiner

Primary Examiner—Kathryn Goygos

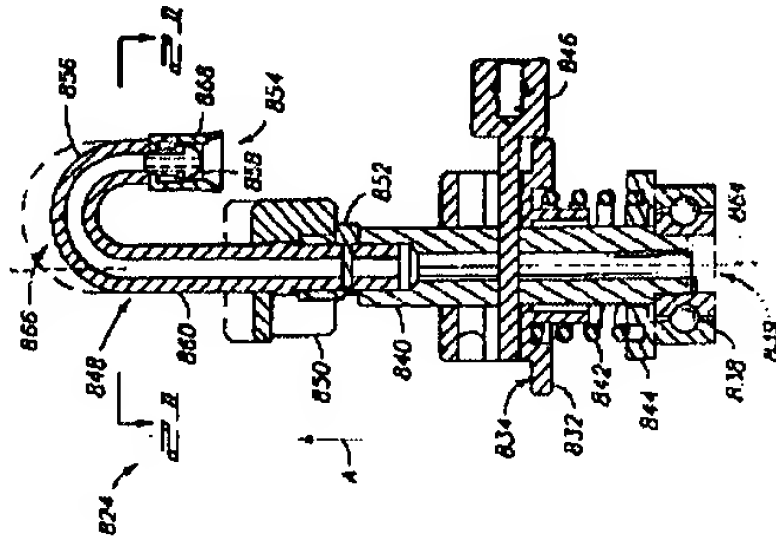
Assistant Examiner—William T. Leader

(74) Attorney, Agent, or Firm—Polit & Associates, LLC

(57) **ABSTRACT**

A semiconductor workpiece holder for use in processing a
semiconductor workpiece includes a workpiece support
operatively mounted to support a workpiece in position for
processing. A finger assembly is operatively mounted upon
the workpiece support and includes a finger tip. The finger
assembly is movable between an engaged position in which
the finger tip is engaged against the workpiece, and a
disengaged position in which the finger tip is moved away
from the workpiece. Preferably, at least one electrode forms
part of the finger assembly and includes an electrode contact
for contacting a surface of said workpiece. At least one
protective sheath covers at least some of the electrode
contact. According to one aspect of the invention, a sheathed
electrode having a sheathed electrode tip is positioned
against a semiconductor workpiece surface in a manner
engaging the workpiece surface with said sheathed electrode
tip and forming a seal.

10 Claims, 20 Drawing Sheets



	Document ID	Pages	B	E	V	S	C	P	Kind Codes	Source
1	US 6274013 B1	34	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
2	US 6001234 A	59	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT

US-PAT-NO:

6274013

DOCUMENT-IDENTIFIER:

US 6274013 B1

TITLE:

Electrode semiconductor workpiece holder

----- KWIC -----

US Patent No. - PN (1):

6274013

US 6,274,013 B1

23

assembly from contact with a plating fluid, said at least one protective sheath being made from a dielectric material, said electrode contact being maintained in a generally retracted position within said at least one protective sheath when said at least one finger assembly is in said disengaged position, said electrode contact being moved out of said retracted position when said at least one finger assembly is moved into said engaged position.

2. The workpiece holder of claim 1 wherein said at least one finger actuator moves said at least one finger assembly in a reciprocal manner.

3. A workpiece holder for use in processing a workpiece comprising:

a workpiece support;

at least one finger assembly mounted upon said workpiece support, said at least one finger assembly including at least one contact for contacting the workpiece;

at least one finger actuator operable with said at least one finger assembly for moving said finger assembly between an engaged position wherein said finger assembly is in contact with the workpiece and a disengaged position wherein said finger assembly is disengaged from the workpiece, said at least one finger actuator having means for moving the at least one finger assembly in an axial movement toward and from the workpiece along a longitudinal axis, and means to rotate the at least one finger assembly in a rotational movement along said longitudinal axis;

at least one electrode forming a part of said at least one finger assembly, said at least one electrode having an electrode contact for contacting a surface of said workpiece to provide electrical connection therewith, wherein said electrode contact is one of said at least one contact;

at least one protective sheath covering at least a portion of the at least one finger assembly to protect the finger assembly from contact with a plating fluid, said at least one protective sheath being made from a dielectric material, said at least one protective sheath including a yieldable terminal adjacent said electrode contact for engaging said workpiece and effectively sealing said electrode contact therewith when said at least one finger assembly is moved to said engaged position said electrode contact being maintained in a generally retracted position within said at least one protective sheath when said at least one finger assembly is in said disengaged position, said electrode contact being moved out of said retracted position when said finger assembly is moved into said engaged position.

4. An apparatus for use in providing electrical power to a substrate while a surface of the substrate is in contact with an electrolyte pursuant to forming one or more microelectronic components on the substrate, the apparatus comprising:

24

one or more substrate support surfaces positioned to support the substrate as the substrate is received by or removed from the apparatus;

a contact assembly comprising

a contact actuator,

a contact member having a first end connected for actuation by the contact actuator and a second end terminating at an electrode, the contact actuator being operable to move the contact member between a first position distal the one or more substrate support surfaces to thereby allow the substrate to be received by or removed from engagement with the one or more substrate support surfaces and a second position in which the electrode is driven into electrical contact with the surface of the substrate that is to contact the electrolyte;

a dielectric sheath disposed proximate the second end of the contact member, the dielectric sheath terminating at a yieldable portion that extends beyond the electrode when the contact member is in the first position so that the electrode is retracted within a volume defined by the yieldable portion, the yieldable portion resiliently deforming when the contact member is moved to the second position, the resilient deformation being sufficient to allow the electrode to extend into electrical contact with the surface of the substrate while concurrently allowing the second end of the dielectric sheath to form a seal with the substrate to prevent the electrode from contacting the electrolyte during substrate processing.

5. The apparatus of claim 4 wherein the contact actuator moves the contact member linearly along and rotationally about a single motion axis when the contact member is moved between the first and second positions.

6. The apparatus of claim 4 wherein the one or more support surfaces are formed by a plurality of support members.

7. The apparatus of claim 4 wherein the apparatus comprises a plurality of contact assemblies.

8. The apparatus of claim 7 wherein the one or more support surfaces are formed by a plurality of support members respectively associated with each of the plurality of contact assemblies.

9. The apparatus of claim 8 wherein the plurality of support members are positioned so that the support surfaces are disposed adjacent the second end of the respective contact member when the contact member is in the second position thereby causing the substrate to be gripped therebetween during processing of the substrate.

10. The apparatus of claim 4 wherein the contact assembly and the one or more support surfaces are mounted to a common frame and extend therefrom in the same direction.

* * * * *

	Document ID	Page	S	U	S	C	P	Kind	Codes	Source
1	US 6461494 B1	61	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			USPAT
2	US 6309524 B1	45	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			USPAT
3	US 6080291 A	21	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			USPAT
4	US 5985126 A	60	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			USPAT
5	US 5980706 A	33	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			USPAT
6	US 0627401 A	3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			USPAT

US-PAT-NO:

5980706

DOCUMENT-IDENTIFIER:

US 5980706 A

TITLE:

Electrode semiconductor workpiece holder

----- KWIC -----

US Patent No. - PN (1):
5980706

5,980,706

21

and disengaged positions is but one manner of effectuating such movement. Other manners of effectuating such movement are possible.

The invention also includes novel methods for presenting a workpiece to a semiconductor process. In such methods, a workpiece is first secured to a workpiece holder. The methods work equally well for workpiece holders known in the art and for the novel workpiece holders disclosed herein.

In the next step in the sequence, the workpiece holder is rotated about a horizontal axis from an initial or first position where the workpiece holder was provided with the workpiece to a second position. The second position will be at an angle to the horizontal. The angle of the workpiece holder to the horizontal is defined by the angle between the plane of the workpiece and the horizontal. In the method, the workpiece holder is advantageously suspended about a second horizontal axis which is parallel to the first horizontal axis of the workpiece holder. At this point in the method, the angle between the first and second horizontal axes and a horizontal plane corresponds to the angle between the workpiece holder and the horizontal. The workpiece holder is then pivoted about the second horizontal axis to move the workpiece and the workpiece holder from its initial location to a final location in a horizontal plane. Advantageously, when the workpiece holder is pivoted about the second horizontal axis, the first horizontal axis also pivots about the second horizontal axis.

Preferably, during the step of rotating the workpiece holder about the first horizontal axis, the angle of the workpiece holder with respect to some known point, which is fixed with respect to the workpiece holder during the rotation process, is continually monitored. Monitoring allows for precise positioning of the workpiece holder with respect to the horizontal surface.

Likewise, during pivoting of the workpiece holder about the second horizontal axis, it is preferable that the angle defined by the line connecting the first and second horizontal axes and the horizontal plane be continually monitored. In this manner, the absolute position of the workpiece holder (and hence the workpiece itself) will be known with respect to the horizontal plane. This is important since the horizontal plane typically will contain the process to which the workpiece will be exposed.

It should be noted that in the above and following description, while the workpiece is described as being presented to a horizontal plane, it is possible that the workpiece may also be presented to a vertical plane or a plane at any angle between the vertical and the horizontal. Typically, the processing plane will be a horizontal plane due to the desire to avoid gravitational effects on process fluids to which the workpiece is exposed. In one embodiment after the workpiece has been presented to the processing plane, the workpiece holder is rotated about a spin axis to cause the workpiece to spin in the horizontal plane. Although not required in all semiconductor manufacturing processes, this is a common step which may be added in the appropriate circumstance.

The next advantageous step in the method consists of pivoting the workpiece holder about the second horizontal axis back along the path that the workpiece holder was initially pivoted along when presenting the workpiece to the horizontal process plane. There is no requirement that the workpiece holder be pivoted back to the same position whence it began, although doing so may have certain advantages as more fully described below.

The method advantageously further consists of the step of rotating the workpiece holder about the first horizontal axis

22

to return the workpiece to the position when it was initially presented to and engaged by the workpiece holder. It is advantageous to rotate the workpiece holder about the first axis in a direction opposite from the initial rotation of the workpiece holder.

The advantage of having the workpiece holder terminate at an end position which corresponds to the initial position when the workpiece was loaded into the workpiece holder is efficiency. That is, additional machine movements are not required to position the workpiece holder to receive a new workpiece.

The method more preferably includes the step of rotating the workpiece holder about the first horizontal axis at least two support points along the first horizontal axis. This beneficially provides support and stability to the workpiece holder during the rotation process and subsequent movement of the apparatus.

The method also more preferably includes the step of pivoting the workpiece holder along with the first horizontal axis about the second horizontal axis at least two support points along the second horizontal axis. This beneficially provides additional support for the workpiece holder while allowing the workpiece holder to be moved in a vertical or "Z-axis" direction.

Importantly, the only motion described in the above method is rotational motion about several axes. In the method described, there is no translational motion of the workpiece holder in a X-, Y-, or Z-axis without corresponding movement in another axis as a result of rotating through an arc.

In compliance with the statute, the invention has been described in language more or less specific as to structural and methodical features. It is to be understood, however, that the invention is not limited to the specific features shown and described, since the means herein disclosed comprise preferred forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims appropriately interpreted in accordance with the doctrine of equivalents.

We claim:

1. A workpiece holder for use in processing a workpiece comprising:

a movable workpiece support mounted for movement between a processing position which is used to support a workpiece in position for processing and an open position wherein the workpiece support is open and available for loading and unloading a workpiece to and from the workpiece support;

at least one finger assembly mounted upon said movable workpiece support, said at least one finger assembly including at least one electrode having an electrode contact for contacting a surface of said workpiece to provide electrical connection therewith;

at least one finger actuator operable with said at least one finger assembly for moving said finger assembly between an engaged position wherein said finger assembly is in contact with the workpiece and a disengaged position wherein said finger assembly is disengaged from the workpiece, said at least one finger actuator having means for moving the at least one finger assembly in an axial movement toward and from the workpiece and means to rotate the at least one finger assembly in a rotational movement.

2. The workpiece holder of claim 1 wherein said at least one finger actuator moves said at least one finger assembly in a reciprocal manner.

	Document ID	Page	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000
--	-------------	------	---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------

US-PAT-NO:

5980706

DOCUMENT-IDENTIFIER:

US 5980706 A

TITLE:

Electrode semiconductor workpiece holder

----- KWIC -----

US Patent No. - PN (1):
5980706

5,980,706

23

3. The workpiece holder of claim 1, wherein said means to rotate the at least one finger assembly rotates the finger assembly about a pivot axis which is aligned with the axial movement produced by said means for moving the at least one finger assembly in an axial movement.

4. The workpiece holder of claim 1 further comprising at least one protective sheath covering at least a portion of the from contact with a plating fluid, said at least one protective sheath being made from a dielectric material.

5. The workpiece holder of claim 4, wherein said at least one protective sheath includes a rim portion for engaging said workpiece and forming a seal therebetween.

6. The workpiece holder of claim 4, wherein said electrode contact is maintained in a generally retracted position within said at least one protective sheath when said at least one finger assembly is in said disengaged position; said electrode contact being moved out of said retracted position when said at least one finger assembly is moved into said engaged position.

7. The workpiece holder of claim 4, wherein said at least one protective sheath includes a yieldable terminal end adjacent said electrode contact for engaging said workpiece and effectively sealing said electrode contact therewithin when said at least one finger assembly is moved to said engaged position; wherein said electrode contact is maintained in a generally retracted position within said at least one protective sheath when said at least one finger assembly is in said disengaged position; said electrode contact being moved out of said retracted position when said at least one finger assembly is moved into said engaged position.

8. The workpiece holder of claim 1, wherein said at least one finger assembly comprises:

a finger assembly frame;

a collet movably mounted on said finger assembly frame for longitudinal reciprocation into and out of said engaged position;

a finger secured to said collet and movable thereby, a portion of said finger extending generally away from said collet; and

a bend in said finger between said collet and said contact.

9. The workpiece holder of claim 1, wherein said movable workpiece support includes a rotor operatively mounted for rotation about a rotor axis; said rotor about said rotor axis for processing.

10. The workpiece holder of claim 1, wherein:

said movable workpiece support includes a rotor operatively mounted for rotation about a rotor axis; said rotor rotating said workpiece for processing; and

there are plural finger assemblies and plural finger actuators.

11. A workpiece holder for use in a plating process to hold and provide electrical contact with a workpiece, comprising:

a movable workpiece support mounted for powered movement between a processing position wherein the workpiece support is placed in relationship with the processing bowl, and an open position wherein the workpiece support is removed from the processing bowl and available for loading and unloading a workpiece to and from the workpiece support;

a workpiece support operator for powering movement of the movable workpiece support between said processing position and said open position;

a rotor mounted for rotational movement upon the movable workpiece support to allow the workpiece support and a workpiece supported thereon to be rotated during processing;

24

at least one finger assembly mounted upon said rotor, said at least one finger assembly including at least one contact for contacting the workpiece;

at least one finger actuator mounted upon the movable workpiece support, said at least one finger actuator being controllably movable to effect movement of the at least one finger assembly between an engaged position wherein the at least one finger assembly engages the workpiece and a disengaged position wherein the at least one finger assembly is disengaged from the workpiece to allow the workpiece to be loaded and unloaded from the workpiece support;

at least one electrode forming a part of said at least one finger assembly, said at least one electrode having an electrode contact for contacting a surface of said workpiece to provide electrical connection therewith, wherein said electrode contact is one of said at least one contact.

12. A workpiece holder according to claim 11 wherein there are a plurality of finger assemblies and finger actuators.

13. A workpiece holder according to claim 11 wherein said at least one finger actuator is controllably engaged and disengaged with the at least one finger assembly mounted upon the rotor.

14. A workpiece holder according to claim 11 wherein said at least one finger actuator includes means for moving the at least one finger assembly in an axial movement toward and from the workpiece.

15. A workpiece holder according to claim 11 wherein said at least one finger actuator includes means to rotate the at least one finger assembly in a rotational movement.

16. A workpiece holder according to claim 11 wherein said at least one finger actuator includes means for moving the at least one finger assembly in an axial movement toward and from the workpiece and means to rotate the at least one finger assembly in a rotational movement.

17. A workpiece holder according to claim 11 and further comprising at least one protective sheath covering at least a portion of the at least one finger assembly to protect the finger assembly from contact with a plating fluid, said at least one protective sheath being made from a dielectric material.

18. A workpiece holder according to claim 17 wherein there are a plurality of finger assemblies and finger actuators.

19. A workpiece holder according to claim 17 wherein said at least one protective sheath includes a rim portion for engaging said workpiece and forming a seal therebetween.

20. A workpiece holder according to claim 17 wherein said electrode contact is maintained in a generally retracted position within said at least one protective sheath when said at least one finger assembly is in said disengaged position; said electrode contact being moved out of said retracted position when said at least one finger assembly is moved into said engaged position.

21. A workpiece holder according to claim 17 wherein said at least one protective sheath includes a yieldable terminal end adjacent said electrode contact for engaging said workpiece and effectively sealing said electrode contact therewithin when said at least one finger assembly is moved to said engaged position; wherein said electrode contact is maintained in a generally retracted position within said at least one protective sheath when said at least one finger assembly is in said disengaged position; said electrode contact being moved out of said retracted position when said finger assembly is moved into said engaged position.

* * * * *

8/2003

	Document ID	Pages	U	S	C	P	Kind Codes	Source
1	US 6461494 B1	61	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
2	US 6309524 B1	45	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
3	US 6080291 A	21	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
4	US 5985126 A	60	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
5	US 5980706 A	33	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
6	US 0627401 A	3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT

US - PAT - NO: 5985126

DOCUMENT-IDENTIFIER: US 5985126 A

TITLE: Semiconductor plating system workpiece support having workpiece engaging electrodes with distal contact part and dielectric cover

----- KWIC -----

US Patent No. - PN (1):
5985126

United States Patent

Bleck et al.

[19]

[11] Patent Number:

5,985,126

[45] Date of Patent:

Nov. 16, 1999

[54] SEMICONDUCTOR PLATING SYSTEM
WORKPIECE SUPPORT HAVING
WORKPIECE ENGAGING ELECTRODES
WITH DISTAL CONTACT PART AND
DIELECTRIC COVER

[75] Inventors: Martin C. Bleck, Bozell, Wash.;
Lyndon W. Graham; Kyle M.
Hanson, both of Kalispell, Mont.

[73] Assignee: Semitool, Inc., Kalispell, Mont.

[21] Appl. No.: 08/988,333

[22] Filed: Sep. 30, 1997

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/680,057, Jul. 15,
1996.

[51] Int. Cl.⁶ C25D 7/12; C25D 17/06

[52] U.S. Cl. 205/123; 204/224 R; 204/297 R;
205/157

[58] Field of Search 205/123, 143,
205/157, 291; 204/224 R, 285, 287, 297 R,
297 W; 118/500, 503, 728, 730

[56] References Cited

U.S. PATENT DOCUMENTS

3,267,010 8/1966 Creutz 205/296
3,328,273 6/1967 Creutz 205/296
3,770,598 11/1973 Creutz 205/296
4,165,252 8/1979 Gibbs 438/694
4,192,729 3/1980 Cancellieri et al. 204/272
4,651,440 3/1987 Karl 34/58
5,024,746 6/1991 Sierman et al. 204/297 W
5,078,852 1/1992 Yee et al. 204/297 R
5,167,792 12/1992 Kaminkshah et al. 205/68
5,168,886 12/1992 Thompson et al. 134/153
5,168,887 12/1992 Thompson et al. 134/153

FOREIGN PATENT DOCUMENTS

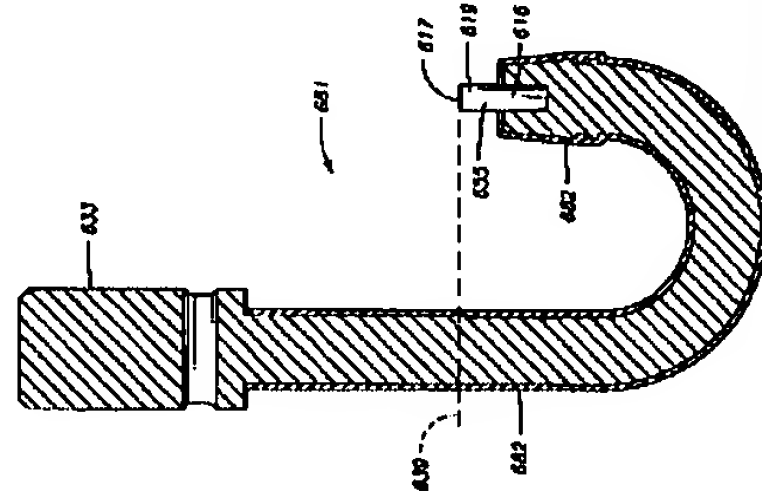
0200210 11/1988 European Pat. Off.
0492772 7/1992 European Pat. Off.
0414791 5/1992 Japan
05320977 12/1993 Japan
WO95/06326 3/1995 WIPO

Primary Examiner—Kathryn Gorgos
Assistant Examiner—William T. Leader
Attorney, Agent, or Firm—Rockey, Milamow & Katz, Ltd.

ABSTRACT

A semiconductor workpiece holder used in electroplating systems for plating metal layers onto a semiconductor workpiece, and is of particular advantage in connection with plating copper onto semiconductor materials. The workpiece holder includes electrode assemblies which have a contact part which connects to a distal end of an electrode shaft and bears against the workpiece and conducts current therebetween. The contact part is preferably made from a corrosion resistant material, such as platinum. The electrode assembly also preferably includes a dielectric layer which covers the distal end of the electrode shaft and seals against the contact part to prevent plating liquid from corroding the joint between these parts.

28 Claims, 38 Drawing Sheets



	Document ID	Page	U	S	C	P	Kind	Source
1	US 6461494 B1	61						USPAT
2	US 6309524 B1	45						USPAT
3	US 6080291 A	21						USPAT
4	US 5985126 A	50						USPAT
5	US 5980706 A	33						USPAT
6	US 0627401 A	3						USPAT

US-PAT-NO: 5985126
DOCUMENT-IDENTIFIER: US 5985126 A

TITLE: Semiconductor plating system workpiece support having workpiece engaging electrodes with distal contact part and dielectric cover

----- KWIC -----

US Patent No. - PN (1):
5985126

5,985,126

39

chamber 345 is sensed by two level detectors 351 and 352. One level detector is used to sense a desired high level and the other is used to sense an overflow condition. The level of liquid is preferably maintained within a desired range for stability of operation. This can be done using several different outflow configurations. A preferred configuration is to sense the high level using detector 351 and then drain fluid through a drain line as controlled by a control valve. It is also possible to use a standpipe arrangement (not illustrated), and such is used as a final overflow protection device in the preferred plating station 303. More complex level controls are also possible.

The outflow liquid from chamber 345 is preferably returned to a suitable reservoir. The liquid can then be treated with additional plating chemicals or other constituents of the plating or other process liquid and used again.

The plating bowl assembly 303 further includes an anode 334. In the preferred uses according to this invention, the anode is a consumable anode used in connection with the plating of copper or other metals onto semiconductor materials. The specific anode will vary depending upon the metal being plated and other specifics of the plating liquid being used. A number of different consumable anodes which are commercially available may be used as anode 334.

FIG. 42 also shows a diffusion plate 375 provide above the anode 334 for rendering the fluid plating bath above the diffusion plate with less turbulence. Fluid passages are provided over all or a portion of the diffusion plate to allow fluid communication therethrough. The height of the diffusion plate is adjustable using three diffuser height adjustment mechanisms 386 and secured by three mounting fasteners 389.

Plating Anode Shield

The invention also includes an anode shield 393 which can be secured to the consumable anode 334 using anode shield fasteners 394. The anode shield and anode shield fasteners are preferably made from a dielectric material, such as polyvinylidene fluoride or polypropylene. The anode shield is advantageously about 2-5 millimeters thick, more preferably about 3 millimeters thick.

The anode shield serves to electrically isolate and physically protect the back side of the anode. It also reduces the consumption of organic plating liquid additives consumed. Although the exact mechanism may not be known at this time, the anode shield is believed to prevent disruption of certain materials which develop over time on the back side of the anode. If the anode is left unshielded the organic chemical plating additives are consumed at a significantly greater rate. With the shield in place these additive are consumed less. The shield is preferably positioned on the anode so as to shield it from direct impingement by the incoming plating liquid.

The invention thus also include methods for plating which include other method steps described herein in combination with shielding a consumable anode from direct flow of plating liquids using a dielectric anode shield.

In compliance with the statute, the invention has been described in language more or less specific as to structural and methodical features. It is to be understood, however, that the invention is not limited to the specific features shown and described, since the means herein disclosed comprise preferred forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims appropriately interpreted in accordance with the doctrine of equivalents.

40

We claim:

1. A semiconductor workpiece holder for use in a semiconductor electroplating apparatus used to plate a metal or metals onto a semiconductor workpiece, comprising:

a workpiece support mounted to support a semiconductor workpiece in position with at least a processed surface of the workpiece being in contact with a plating bath; at least one electrode finger which is electrically conductive and capable of receiving and conducting electrical current therethrough; said at least one electrode finger having an electrode shaft which extends toward a distal end;

a contact part mounted to the distal end of the electrode shaft to provide an electrical contact face which bears upon the semiconductor workpiece during processing to communicate electrical current therethrough.

2. A semiconductor workpiece holder according to claim 1 wherein said contact part is made from a corrosion resistant metal.

3. A semiconductor workpiece holder according to claim 1 wherein said contact part is made from platinum.

4. A semiconductor workpiece holder according to claim 1 wherein said electrode shaft is made from a stainless steel or titanium.

5. A semiconductor workpiece holder according to claim 1 wherein:

said contact part is made from platinum;

said electrode shaft is made from a stainless steel or titanium.

6. A semiconductor workpiece holder according to claim 1 and further comprising a dielectric layer formed about at least the distal end of the electrode shaft and forming a seal against side walls of the contact part to exclude plating liquid from a joint formed between the electrode shaft and the contact part.

7. A semiconductor workpiece holder according to claim 1 and further comprising a dielectric layer formed from a dielectric plastic material about at least the distal end of the electrode shaft and forming a seal against side walls of the contact part to exclude plating liquid from a joint formed between the electrode shaft and the contact part.

8. A semiconductor workpiece holder according to claim 1 and further comprising a dielectric layer formed from polyvinylidene fluoride about at least the distal end of the electrode shaft and forming a seal against side walls of the contact part to exclude plating liquid from a joint formed between the electrode shaft and the contact part.

9. A semiconductor workpiece holder according to claim 1 and further comprising a dielectric layer coated about at least the distal end of the electrode shaft and forming a seal against side walls of the contact part to exclude plating liquid from a joint formed between the electrode shaft and the contact part.

10. A semiconductor workpiece holder for use in a semiconductor electroplating apparatus used to plate a copper material onto a semiconductor workpiece, comprising:

a workpiece support mounted to support a semiconductor workpiece in position with at least a processed surface of the workpiece being in contact with a plating bath; at least one electrode finger which is electrically conductive and capable of receiving and conducting electrical current therethrough; said at least one electrode finger having an electrode shaft which extends toward a distal end;

a contact part mounted to the distal end of the electrode shaft to provide an electrical contact face which bears

	Document ID	Pages	1	2	3		U.S.	C.	P.	Kind Codes	Source
1	US 6461494 B1	61									USPAT
2	US 6309524 B1	45									USPAT
3	US 6080291 A	21									USPAT
4	US 5985126 A	60									USPAT
5	US 5980706 A	33									USPAT
6	US 0627401 A	3									USPAT

US-PAT-NO: 6080291
DOCUMENT-IDENTIFIER: US 6080291 A

TITLE: Apparatus for electrochemically processing a workpiece including an electrical contact assembly having a seal member

----- KWIC -----

US Patent No. - PN (1):
6080291

United States Patent [19] **Patent Number:** 6,080,291
Woodruff et al. [45] **Date of Patent:** Jun. 27, 2000

Primary Examiner: Kathryn Gorgos
Assistant Examiner: Erica Smith-Hicks
Attorney, Agent, or Firm: Rockey, Milnamow & Katz, Ltd.

ABSTRACT

A plating apparatus, such as for electroplating of semiconductor wafers or like workpieces, includes a plating contact including an annular contact ring having an annular mounting portion, and an annular electrically-conductive contact portion extending inwardly of the mounting portion. The contact portion is configured for substantially continuous electrically-conductive contact with a peripheral region of the associated workpiece. The arrangement further includes an annular seal member mounted on the annular contact ring, with the seal member including a resiliently deformable annular seal lip portion adjacent to the contact portion of the contact ring. The seal lip is resiliently biased into continuous sealing engagement with the peripheral region of the workpiece when the workpiece is positioned in electrically-conductive contact with the contact ring. The apparatus includes a robot assembly configured to receive the workpiece, and move the workpiece into operative contact with the annular contact ring and the annular seal member.

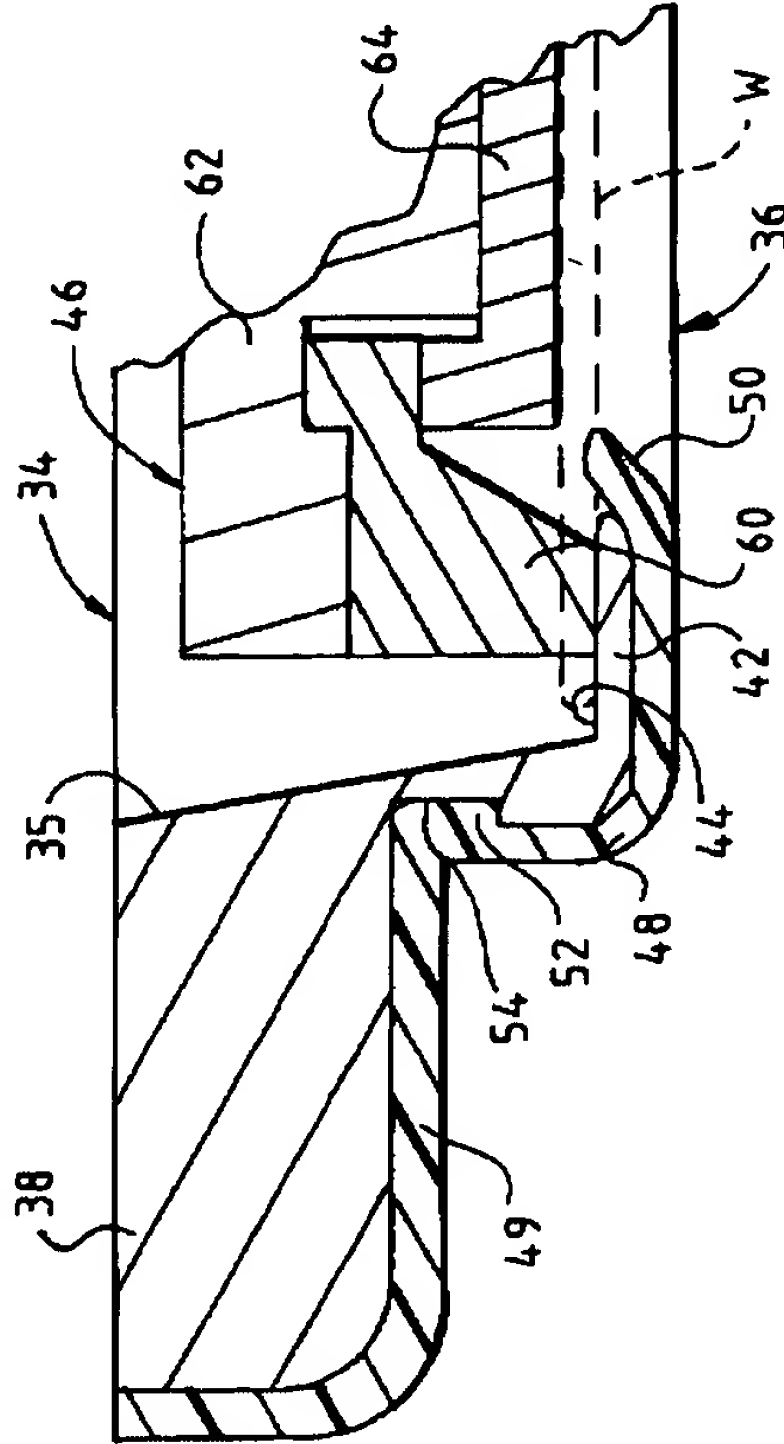
8 Claims, 13 Drawing Sheets

FOREIGN PATENT DOCUMENTS

WO 99/25904 5/1999 WIPO

References Cited
U.S. PATENT DOCUMENTS

4,246,088 1/1981 Murphy et al.
4,259,166 3/1981 Whitehurst
4,304,641 12/1981 Granda et al.
4,466,864 8/1984 Bacon et al.
5,135,636 8/1992 Yee et al.
5,227,041 7/1993 Brogden et al.
5,441,629 8/1995 Kosaki
5,744,019 4/1998 Aug



		Document ID	Page	1	2	3	4	5	6	7	8	9	U	S	C	P	Kind Codes	Source
1		US 6461494 B1	61	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
2		US 6309524 B1	45	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
3		US 6080291 A	21	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
4		US 5985126 A	60	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
5		US 5980706 A	33	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
6		US 0627401 A	3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT

US-PAT-NO: 6080291

DOCUMENT-IDENTIFIER: US 6080291 A

TITLE: Apparatus for electrochemically processing a workpiece including an electrical contact assembly having a seal member

----- KWIC -----

US Patent No. - PN (1):
6080291

6,080,291

11

By this arrangement, the actuation ring 82 of the detachable portion 70 can be coupled to, and uncoupled from, the actuation coupling 106 of the rotor assembly.

Actuation coupling 106 is movable in a direction in opposition to the biasing springs 86 by a plurality of pneumatic actuators 108 mounted on a frame 110 of the rotor assembly. Each actuator 108 is operatively connected with the actuation coupling 106 by a respective drive member 112, each of which extends generally through the frame 110 on which motor 102 is mounted.

Operation of the rotor assembly 28 will be appreciated from the above description. Loading of workpiece W into the rotor assembly is effected with the rotor assembly in a generally upwardly facing orientation, such as illustrated in FIGS. 2 and 13. Workpiece W is moved transversely through the opening 76 defined by the rotor assembly to a position wherein the workpiece is positioned in spaced relationship generally above supports 80. The robotic arm 32 is then lowered (with clearance opening 78 accommodated through movement), whereby the workpiece is positioned upon the supports 80. The robotic arm can then be withdrawn from within the rotor assembly.

The workpiece is now moved perpendicularly to the first direction in which it is moved transversely into the rotor assembly. Such movement is effected by movement of backing member 46 generally toward contact ring 34 and seal member 36. It is presently preferred that pneumatic actuators 102 act in opposition to biasing springs 86 which are operatively connected by actuation ring 82 and shafts 84 to the backing member 46. Thus, actuators 108 are operated to permit springs 86 to bias and urge actuation ring 82, and thus backing member 46, toward contact ring 34. FIG. 13 illustrates the disposition of the workpiece W within the rotor assembly after it is received therein on supports 80, while FIG. 14 illustrates the disposition of the workpiece after it has been moved by backing member 46, under the influence of springs 86, into the processing position. As will be observed, the workpiece is moved into electrically conductive relationship with the contact portion 42 of the contact ring 34, with seal member 36 sealingly engaging the peripheral portion of the workpiece. The workpiece is held firmly in position against the contact member under the influence of springs 86, while pneumatic actuators 108 are depressurized.

In the preferred form, the connection between actuation ring 82 and backing member 46, by shafts 84, permits some "float", that is, the actuation ring and backing member are not rigidly joined to each other. This preferred arrangement accommodates the common tendency of the pneumatic actuators 108 to move at slightly different speeds, thus assuring that the workpiece is urged into substantial uniform contact with the contact member 34, while avoiding excessive stressing of the workpiece, or binding of the actuation mechanism.

With the workpiece firmly held between the backing member 46 and the contact ring 34 (and seal member 36), lift and rotate apparatus 30 rotates the rotor assembly 28, and rotates and lowers the rotor assembly into cooperative position with reactor vessel 12 so that the surface of the workpiece is placed in contact with plating solution within the reactor vessel. FIG. 18 illustrates the apparatus in this condition. Because the peripheral seal 36 acts to seal the entire peripheral region of the workpiece, it is important that any gas which accumulates on the surface of the workpiece be permitted to vent and escape. Accordingly, practice of the present invention contemplates that the surface of the work-

12

piece be disposed at an acute angle (angle "alpha" in FIG. 18), such as on the order of two degrees from horizontal, with respect to the surface of the solution in the reactor vessel. This facilitates venting of gas from the surface of the workpiece during the plating process as the workpiece, and associated backing and contact members, are rotated in unison by motor 102 acting through drive shaft 100 and the housing assembly 72, 73. Circulation of plating solution within the reactor vessel, as electrical current is passed through the workpiece and the plating solution, effects the desired electroplating of a metal layer on the surface of the workpiece.

A number of features of the present invention facilitate efficient and cost-effective electroplating of workpieces such as semiconductor wafers. By use of a contact ring having substantially continuous contact, either in the form of continuous contact ring 34, or contact ring 134 having discrete contact regions, a high number of plating contacts are provided while minimizing the required number of components. The actuation of the backing member 46 is desirably effected by a simple linear motion, thus facilitating precise positioning of the workpiece, and uniformity of contact with the contact ring. The illustrated arrangement desirably minimizes the "penetrations" through the rotor assembly into the chemical environment within the reactor vessel, thereby desirably minimizing the required sealing of these regions. Disassembly is facilitated by the detachable configuration of the portion 70 of the rotor assembly, with the arrangement further facilitating the provision of different contact configurations by simply changing the contact ring 34, 134. The ring contact provides ideal distribution of contact onto the surface of the workpiece, while the preferred provision of the peripheral seal can protect the contact from plating solution, thereby desirably preventing build-up of plated material onto the electrical contacts. The perimeter seal also desirably prevents plating onto the peripheral portion of the workpiece. The contact assembly is desirably formed from a minimum number of components, and contact with the workpiece can be tightly controlled, which is important in those applications in which only a specified region of the workpiece is provided by electric contact.

From the foregoing, it will be observed that numerous modifications and variations can be made without departing from the true spirit and scope of the novel concept of the present invention. It will be understood that no limitation with respect to the specific embodiments illustrated herein is intended or should be inferred. The disclosure is intended to cover, by the appended claims, all such modifications as fall within the scope of the claims.

What is claimed is:

1. An electrical contact assembly for an apparatus for effecting electrochemical processing of a workpiece, comprising:

an annular contact for mounting on said apparatus, said annular contact having an annular mounting portion, and an annular electrically-conductive contact portion extending inward of said mounting portion, said conductive contact portion being configured for electrically-conductive contact with a peripheral region of said workpiece at a substantial number of contact points; and

an annular seal member mounted on said annular contact, the annular seal member comprising an annular seal lip formed entirely from a resiliently deformable material, the annular seal lip comprising an upstanding portion in fixed alignment with the annular mounting portion of the annular contact and a radially extending portion

	Document ID	Page	U	S	C	P	Kind Codes	Source
1	US 6461494 B1	61	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
2	US 6309524 B1	15	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
3	US 6080291 A	21	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
4	US 5985126 A	60	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
5	US 5980706 A	33	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
6	US 0627401 A	3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT

US-PAT-NO:

6309524

DOCUMENT-IDENTIFIER: US 6309524 B1

See image for Certificate of Correction

TITLE:

Methods and apparatus for processing the surface of a
microelectronic workpiece

----- KWIC -----

US Patent No. - PN (1):

6309524

United States Patent

Woodruff et al.

(10) Patent No.: US 6,309,524 B1

(45) Date of Patent: *Oct. 30, 2001

**(54) METHODS AND APPARATUS FOR
PROCESSING THE SURFACE OF A
MICROELECTRONIC WORKPIECE**

(75) Inventors: Daniel J. Woodruff; Kyle M. Hanson;
Thomas H. Oberlitter; LinLin Chen;
John M. Pedersen, all of Kalispell, MT
(US); Vladimir Zila, Scarborough (CA)

(73) Assignee: Semitool, Inc., Kalispell, MT (US)

(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(e)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 09/386,610

(22) Filed: Aug. 31, 1999

Related U.S. Application Data

(63) Continuation of application No. PCT/US99/15847, filed on Jul. 12, 1999, which is a continuation of application No. 09/113,723, filed on Jul. 10, 1998, now Pat. No. 6,080,291.

(60) Provisional application No. 60/111,232, filed on Dec. 7, 1998, and provisional application No. 60/119,668, filed on Feb. 11, 1999.

(51) Int. Cl.: C25D 17/04; C25D 17/06

(52) U.S. Cl.: 204/297.1; 204/297.09

(58) Field of Search: 8204/297 R, 279, 204/297.01, 297.09, 297.06, 297.1

References Cited**U.S. PATENT DOCUMENTS**

4,137,867 2/1979 Algo 118/627
4,246,088 1/1981 Murphy et al. 204/181 R
4,259,166 3/1981 Whitehurst 204/279
4,304,641 12/1981 Grandia et al. 204/23

4,341,629 7/1982 Uhlinger 210/128
4,466,864 8/1984 Bacon et al. 204/115
4,576,685 3/1986 Goffredo et al. 204/30
4,685,414 8/1987 Dillco 118/46
4,913,085 4/1990 Vohringer et al. 118/312
5,135,636 8/1992 Yee et al. 205/96

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

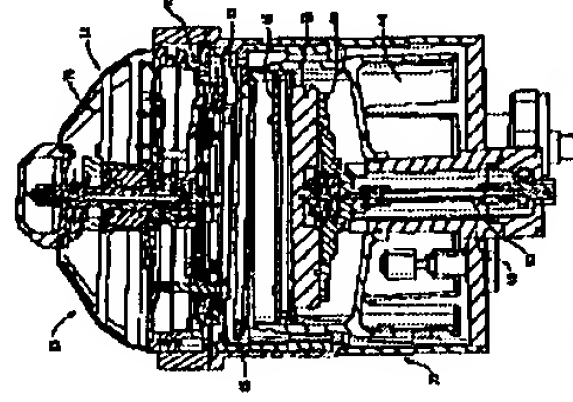
WO99/25904 5/1999 (WO)
WO99/25905 8/1999 (WO)
WO00/32835 6/2000 (WO)

Primary Examiner—Donald R. Valentine
Assistant Examiner—Erica Smith-Hicks
(74) Attorney, Agent, or Firm—Perkins Coie LLP

(57) ABSTRACT

A reactor for plating a metal onto a surface of a workpiece is set forth. The reactor comprises a reactor bowl including an electroplating solution disposed therein and an anode disposed in the reactor bowl in contact with the electroplating solution. A contact assembly is spaced from the anode within the reactor bowl. The contact assembly includes a plurality of contacts disposed to contact a peripheral edge of the surface of the workpiece to provide electroplating power to the surface of the workpiece. The contacts execute a wiping action against the surface of the workpiece as the workpiece is brought into engagement therewith. The contact assembly also includes a barrier disposed interior of the plurality of contacts. The barrier includes a member disposed to engage the surface of the workpiece to assist in isolating the plurality of contacts from the electroplating solution. In one embodiment, the plurality of contacts are in the form of discrete flexures while in another embodiment the plurality of contacts are in the form of a Belleville ring contact. A flow path may be provided in the contact assembly for providing a purging gas to the plurality of contacts and the peripheral edge of the workpiece. The purging gas may be used to assist in the formation of the barrier of the contact assembly. A combined electroplating/electroless plating tool and method are also set forth.

39 Claims, 26 Drawing Sheets



	Document ID	Page	3	U	S	C	P	Kind Codes	Source
1	US 6461494 B1	61	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
2	US 6309524 B1	45	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
3	US 6080291 A	21	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
4	US 5985126 A	60	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
5	US 5980706 A	33	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
6	US 0627401 A	3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT

US-PAT-NO: 6309524
DOCUMENT-IDENTIFIER: US 6309524 B1
See image for Certificate of Correction
TITLE: Methods and apparatus for processing the surface of a microelectronic workpiece

----- KWIC -----
US Patent No. - PN (1):
6309524

US 6,309,524 B1

25

may be supplied directly through a hollowed region of drive shaft 360 as opposed to an intermediate tube. Depending on the particular implementation of the rotor assembly 75, communication of the purging gas may then proceed to the purge port through a corresponding tube or through a hollow channel formed in a substantially solid body member that spans therebetween.

Communication of the purging gas from purge port 725 to the isolated regions of the corresponding workpiece holder or contact assembly is illustrated in FIG. 46. As shown, purge port 725 opens to a purge passageway 735 that is disposed through an outer housing of the rotor assembly 75. The purge passageway 735 opens to an inlet port 740 of the workpiece holder or contact assembly (such inlet ports are also illustrated in the embodiments of the workpiece holders and contact assemblies described above). From such inlet ports, the purge gas flows through the particular holder or contact assembly in the manner described above.

Integrated Plating Tool

FIGS. 47 through 49 are top plan views of integrated processing tools, shown generally at 1450, 1455, and 1500 that may incorporate electroless plating reactors and electroplating reactors as a combination for plating on a microelectronic workpiece, such as a semiconductor wafer. Processing tools 1450 and 1455 are each based on tool platforms developed by Semitool, Inc., of Kalispell, Mont. The processing tool platform of the tool 450 is sold under the trademark LT-210™, the processing tool platform of the tool 1455 is sold under the trademark LT-210C™, and the processing tool 1500 is sold under the trademark EQUI-NOX™. The principal difference between the tools 1450, 1455 is in the footprints required for each. The platform on which tool 1455 is based has a smaller footprint than the platform on which tool 1450 is based. Additionally, the platform on which tool 1450 is based is modularized and may be readily expanded. Each of the processing tools 1450, 1455, and 1500 are computer programmable to implement user entered processing recipes.

Each of the processing tools 1148, 1455, and 1500 include an input/output section 1460, a processing section 1465, and one or more robots 1470. The robots 1470 for the tools 1450, 1455 move along a linear track. The robot 1470 for the tool 1500 is centrally mounted and rotates to access the input/output section 1460 and the processing section 1465. Each input/output section 1460 is adapted to hold a plurality of workpieces, such as semiconductor wafers, in one or more workpiece cassettes. Processing section 1465 includes a plurality of processing stations 1475 that are used to perform one or more fabrication processes on the semiconductor wafers. The robots 1470 are used to transfer individual wafers from the workpiece cassettes at the input/output section 1460 to the processing stations 1475, as well as between the processing stations 1475.

One or more of the processing stations 1475 can be configured as electroless plating reactor 1475a such as heretofore described, and one or more of the processing stations can be configured as electroplating assemblies, 1475b such as the electroplating reactor described above. For example, each of the processing tools 1450 and 1455 may include three electroless plating reactors, three electroplating reactors and one or more pre-wet/rinse station or other processing vessel. The pre-wet/rinse station is preferably one of the type available from Semitool, Inc. It will now be recognized that a wide variation of processing station configurations may be used in each of the individual processing tools 450, 455, and 500 to execute electroless plating and electroplating processes. As such, the foregoing configurations are merely illustrative of the variations that may be used.

26

Plating Method Using Electroless Plating and Electroplating
According to a method of the present invention, workpieces, such as semiconductor wafers, having first been processed to have a seed layer applied thereon, are electrolessly plated and then electroplated. The method is schematically described in FIG. 50.

A barrier layer is first applied (step 1) to features on a surface of a workpiece. The barrier layer can be applied by PVD or CVD processes. A seed layer is then applied (step 2) onto the barrier layer. The seed layer is preferably a Cu seed layer applied by a PVD or CVD processes. After the seed layer is applied, the workpiece can be placed in an electroless plating reactor as described below. An electroless plating bath is provided in the reactor and the workpiece is exposed to the plating bath to plate a conductive layer, preferably copper, thereon (step 3). The conductive layer is applied as a blanket to the extent that small and high aspect ratio vias and trenches are filled, but not to the extent that large vias and trenches are completely filled. By terminating the electroless plating at this point, a shorter time period in the overall process can be achieved. The workpieces having the electrolessly plated conductive layer thereon are then removed from the electroless plating reactor and transferred to an electroplating reactor wherein a further conductive layer, preferably copper is applied over the electrolessly plated conductive layer (step 4). The electroplating process has a higher deposition rate and has adequate filling conformity to fill the larger trenches and vias.

The electroless plating recipe can be a known recipe such as disclosed in the background section of this application in the article by V. M. Dubin, et al., or as describe in U.S. Pat. Nos. 5,500,315; 5,310,580; 5,389,496; or 5,139,818, all incorporated herein by reference. Further, the foregoing processing sequence can be carried out in any of the tools illustrated in FIGS. 47-49.

Numerous modifications may be made to the foregoing system without departing from the basic teachings thereof. Although the present invention has been described in substantial detail with reference to one or more specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the scope and spirit of the invention as set forth in the appended claims.

What is claimed is:

1. A contact assembly for providing electrical contact between a workpiece and a source of electrical power, the contact assembly comprising:
 - a body member having an inner wall defining an open region sized larger than the workpiece;
 - a contact system having a plurality of cantilevered spring contacts extending at least generally radially inwardly with respect to the inner wall to a location in the open region; and
 - a barrier member having a radially transverse portion projecting inwardly from the body and into the open region, the barrier having a lip radially inwardly from the spring contacts defining a processing aperture sized smaller than the workpiece, wherein the lip is configured to contact the workpiece.
2. A contact assembly as claimed in claim 1 wherein the plurality of contacts are in the form of discrete flexure contacts.
3. A contact assembly as claimed in claim 2 wherein the flexure contacts extend radially inward toward the center.
4. A contact assembly as claimed in claim 1 wherein the spring contacts extend inward at an angle with respect to a radius of the processing aperture.

	Document ID	Page	U	S	G	P	Kind Codes	Source
1	US 6461494 B1	61	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
2	US 6309524 B1	45	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
3	US 6080291 A	21	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
4	US 5985126 A	60	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
5	US 5980706 A	33	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
6	US 0627401 A	3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT

US-PAT-NO:

6309524

DOCUMENT-IDENTIFIER: US 6309524 B1

See image for Certificate of Correction

TITLE:

Methods and apparatus for processing the surface of a
microelectronic workpiece

----- KWIC -----

US Patent No. - PN (1):
6309524

US 6,309,524 B1

27

5. A contact assembly as claimed in claim 2 wherein some of the flexure contacts have a greater length than the remaining flexure contacts.

6. A contact assembly as claimed in claim 2 wherein at least some of the plurality of flexure contacts each include an upstanding portion, a transverse portion, a vertical portion, and a wiper contact portion.

7. A contact assembly as claimed in claim 1 wherein the plurality of contacts are adapted for executing a wiping action against the surface of the workpiece as the workpiece is brought into engagement with the contacts.

8. A contact assembly as claimed in claim 1 further comprising a contact support member for capturing at least a portion of the plurality of contacts within a channel defined between the contact support member and the outer body member, the contact support member being disposed radially interior of the outer body member.

9. A contact assembly as claimed in claim 8 wherein the contact support member includes a groove, and the contact assembly further comprises a wedge member disposed to engage said groove along with the discrete flexures to thereby secure the contacts with the contact support member.

10. A contact assembly as claimed in claim 9 wherein at least a portion of the wedge member assists in stiffening the flexing of the contacts as a workpiece is brought into engagement with the contact assembly.

11. A contact assembly as claimed in claim 1 wherein the plurality of contacts are comprised of planarized titanium.

12. A contact assembly as claimed in claim 1 wherein the outer body is comprised of a dielectric material.

13. A contact assembly as claimed in claim 1 wherein the plurality of flexure contacts are integrated with a corresponding common ring.

14. A contact assembly as claimed in claim 1, wherein the contacts are in the form of a Belleville ring contact.

15. A contact assembly as claimed in claim 1 wherein the barrier member comprises a lip formed integrally with the outer body member adapted for engaging the surface of the workpiece.

16. A contact assembly as claimed in claim 1 wherein the barrier member comprises an elastomeric seal member supported by the outer body member, the elastomeric seal member adapted for engaging the surface of the workpiece.

17. The contact assembly of claim 1 wherein the contact system further comprises a conductive ring and the cantilevered spring contacts of the contact system comprise fingers integral with the conductive ring that project radially inwardly along a radius of the open region and upwardly at an acute angle with respect to a plane defined by the open region of the body.

18. The contact assembly of claim 1 wherein the contact system further comprises a conductive ring and the cantilevered spring contacts of the contact system comprise fingers integral with the conductive ring that project generally radially inwardly from the conductive ring at an angle with respect to a radius of the open region and upwardly at an acute angle with respect to a plane defined by the open region of the body.

19. The contact assembly of claim 1 wherein the contact system further comprises a conductive ring and the cantilevered spring contacts of the contact system comprise fingers integral with the conductive ring that project radially inwardly from the conductive ring along a radius of the open region.

20. The contact assembly of claim 1 wherein the cantilevered spring contacts of the contact system comprise

28

individual flexure members attached to the body by a wedge, the flexure members having a cantilevered finger projecting radially inwardly from the body to an interior portion of the open region.

21. A contact assembly for providing electrical contact between a workpiece and a source of electrical power in electroplating applications, the contact assembly comprising:

a conductive mount member having a generally annular shape with an opening sized to receive the workpiece, the mount member being the primary support structure of the contact assembly;

a dielectric outerbody attached to the mount member, the outerbody having a barrier section projecting inwardly with respect to the mount member to an interior lip sized to engage a perimeter portion of the workpiece; and

a plurality of flexing contact members electrically coupled to the mount member, the flexing contact members having a first end at least proximate to the mount member and a second end projecting inwardly from the first end to a location between the interior lip of the outerbody and the mount member, the first end of the contact members defining contact points that engage the workpiece and elastically couple the workpiece to the mount member.

22. A contact assembly for providing electrical contact between a workpiece and a source of electrical power in electroplating applications, the contact assembly comprising:

a primary support structure, the primary support structure being a conductive ring having an outer annular surface, an inner annular surface, a top surface and a bottom surface, the inner annular surface being sized to allow the workpiece to pass through the primary support structure;

an outerbody attached to the primary support structure, the outerbody having an annular barrier section projecting radially inwardly with respect to the inner annular surface of the primary support structure to an interior lip sized to engage a perimeter portion of the workpiece; and

a contact system having a plurality of contact members electrically coupled to the primary support structure, the contact members having a first end at least proximate to the inner annular surface of the primary support structure and a second end defining a contact point to electrically engage the workpiece, the first ends of the contact members being generally stationary relative to the primary support structure and the second ends of the contact members projecting inwardly from the first ends to locations between the interior lip of the outerbody and the inner annular surface.

23. The contact assembly of claim 22 wherein the plurality of contact members comprises individual flexure members spaced apart from one another around the primary support structure, each flexure member having an upstanding portion contacting the support structure and a transverse portion projecting inwardly from the upstanding portion to extend inwardly with respect to the inner annular surface of the primary support member.

24. The contact assembly of claim 22 wherein the contact system further comprises a conductive arcuate member and the contact members comprise a plurality of generally flat fingers projecting inwardly from the conductive arcuate member, the conductive arcuate member being coupled to

	Document ID	Page	US	S	O	P	Kind	Codes	Source
1	US 6461494 B1	61	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
2	US 6309524 B1	45	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
3	US 6080291 A	21	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
4	US 5985126 A	60	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
5	US 5980706 A	33	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT
6	US 0627401 A	3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		USPAT

US-PAT-NO:

6309524

DOCUMENT-IDENTIFIER: US 6309524 B1

++See image for Certificate of Correction++

TITLE:

Methods and apparatus for processing the surface of a microelectronic workpiece

----- KWIC -----

US Patent No. - PN (1):
6309524

US 6,309,524 B1

29

the primary support structure so that the fingers extend generally radially inwardly with respect to the inner annular surface of the primary support structure upwardly at an acute angle with respect to a plane defined by the bottom surface of the primary support structure.

25. A contact assembly for providing electrical contact between a workpiece and a source of electrical power, the contact assembly comprising:

a primary support structure having an outer wall, an inner wall, a first surface between the outer wall and the inner wall, and a second surface between the outer wall and the inner wall, wherein the inner wall defines a receiving opening larger than the microelectronic workpiece;

a barrier projecting inwardly with respect to the inner wall of the primary support structure to an interior lip configured to engage a perimeter portion of the workpiece, the interior lip of the barrier section defining a processing opening smaller than the microelectronic workpiece; and

a conductive contact system attached to the primary support structure, the contact system having a plurality of contact members that have a base end at least proximate to the primary support structure and a contact end projecting inwardly with respect to the inner wall to a location between the interior lip of the outerbody and the inner wall, wherein the contact members flex about the base ends toward the barrier section when the workpiece engages the contact ends and moves through the receiving opening toward the second surface of the primary support member.

26. The contact assembly of claim 25 wherein:

the primary support structure comprises an electrically conductive ring; and

the barrier comprises a dielectric outer body attached to the electrically conductive ring.

27. The contact assembly of claim 25 wherein the contact system further comprises an annular conductive ring having an opening and the contact members comprise a plurality of cantilevered tabs projecting inwardly from the conductive ring toward the opening.

28. The contact assembly of claim 25 wherein the contact system comprises a plurality of individual flexure members such that each flexure member defines a contact member.

29. A contact assembly for providing electrical contact between a workpiece and a source of electrical power in electroplating applications, the contact assembly comprising:

a primary support structure having an inner wall defining an open region sized larger than the workpiece; and

a contact system coupled to the primary support structure, the contact system having a plurality of cantilevered spring contacts extending at least generally radially inwardly with respect to the inner wall to a location in the open region, the cantilevered spring contacts having a pivoting end at least proximate to the primary support structure and a contact end in the open region, wherein the cantilevered spring contacts flex as a workpiece engages the contact ends and moves through the open region causing the contact ends to move laterally across a front surface of the workpiece.

30. The contact assembly of claim 29 wherein the contact system further comprises a conductive ring, and wherein the pivoting ends of the spring contacts are integral with the conductive ring and the contact ends of the spring contacts project radially inwardly from the conductive ring along a radius of the open region.

30

31. The contact assembly of claim 29 wherein the contact system further comprises a conductive ring, and wherein the pivoting ends of the spring contacts are integral with the conductive ring and the contact ends of the spring contacts project generally radially inwardly from the conductive ring at an angle with respect to a radius of the open region.

32. The contact assembly of claim 29 wherein the contact system further comprises a conductive ring, and wherein the pivoting ends of the spring contacts are integral with the conductive ring and the contact ends of the spring contacts project radially inwardly from the conductive ring along a radius of the open region and upwardly at an acute angle with respect to a plane defined by the open region.

33. The contact assembly of claim 29 wherein the contact system further comprises a conductive ring, and wherein the pivoting ends of the spring contacts are integral with the conductive ring and the contact ends of the spring contacts project generally radially inwardly from the conductive ring at an angle with respect to a radius of the open region and upwardly at an acute angle with respect to a plane defined by the open region.

34. The contact assembly of claim 29, further comprising a barrier having a transverse section projecting radially inwardly with respect to the inner wall of the primary support structure to an interior lip radially inward of the contact ends of the contact members, wherein the lip of the barrier is configured to engage a perimeter portion of the workpiece.

35. The contact assembly of claim 34 wherein:

the primary support structure comprises an electrically conductive ring; and

the barrier comprises a flexible dielectric outer-body having a first section attached to the primary support structure and a second section extending transverse to the first section, the second section of the dielectric outer-body defining the transverse section of the barrier.

36. The contact assembly of claim 35 wherein the contact system further comprises a conductive ring, and wherein the pivoting ends of the spring contacts are integral with the conductive ring and the contact ends of the spring contacts project radially inwardly from the conductive ring along a radius of the open region.

37. The contact assembly of claim 35 wherein the contact system further comprises a conductive ring, and wherein the pivoting ends of the spring contacts are integral with the conductive ring and the contact ends of the spring contacts project generally radially inwardly from the conductive ring at an angle with respect to a radius of the open region.

38. The contact assembly of claim 35 wherein the contact system further comprises a conductive ring, and wherein the pivoting ends of the spring contacts are integral with the conductive ring and the contact ends of the spring contacts project radially inwardly from the conductive ring along a radius of the open region and upwardly at an acute angle with respect to a plane defined by the open region.

39. The contact assembly of claim 35 wherein the contact system further comprises a conductive ring, and wherein the pivoting ends of the spring contacts are integral with the conductive ring and the contact ends of the spring contacts project generally radially inwardly from the conductive ring at an angle with respect to a radius of the open region and upwardly at an acute angle with respect to a plane defined by the open region.

• • • • •